Journal of Cleaner Production 178 (2018) 314–324

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Prevention, mitigation and adaptation to climate change from perspectives of urban population in an emerging economy

Clara Ines Pardo Martínez [a, b, *], William H. Alfonso Piña [c], Sylvia Fletscher Moreno [b, d]

[a] School of Administration, Universidad del Rosario, Bogotá, Colombia
[b] Colombian Observatory of Science and Technology (OCyT), Bogotá, Colombia
[c] Faculty of Science Policy and Government, Urban Development and Management, Universidad del Rosario, Bogotá, Colombia
[d] Colombia Universidad Externado de Colombia, Bogotá, Colombia

ARTICLE INFO

Article history:
Received 23 April 2017
Received in revised form
16 December 2017
Accepted 28 December 2017
Available online 4 January 2018

Keywords:
Climate change
Urban public ideas and knowledge
Bogotá, Survey

ABSTRACT

This paper discusses the current knowledge and opinions of urban population in a city of a country that it is recognized with greater vulnerability to climate change, as it is Bogotá the main city of Colombia. It is important to analyse the opinion of the urban population on climate change, taking into account that in the next years cities will be vulnerable and affected by this phenomenon. This research uses a survey that determine the knowledge, causes and effects of climate change, as well as measurements and information that are required to address climate change issues more fully. The main results suggest that the Bogotá's respondents have heard about climate change and all consider that this phenomenon is a reality. The main effects of climate change according to respondents are droughts and floods, with consequences for health and water, energy and food availability. Moreover, the respondents consider the design and application of adequate measurements that allow adaptation and mitigation to climate change important. The findings of this study are significant for awareness at all levels of urban society of the activities and programs that allow for sustainable development in consideration of climate change.

© 2018 Elsevier Ltd. All rights reserved.

1. Introduction

Urban areas or cities arise from the transformation of natural ecosystem into a built environment and today are particularly exposed and vulnerable to climate change (Revie et al., 2014; Weyrich, 2016). More than half of the world population currently lives in cities, which have increased urbanization process and the exposition to direct climate change impacts and consequences today and the future (United Nations Department of Economic and Social Affairs, 2014; Hunt and Watkiss, 2011). Moreover, fast urbanization in developing countries has already increased the number of greatly vulnerable urban communities living in informal settlements, many of which are at high risk from extreme weather events (Staden, 2014).

Hundreds of millions of urban residents in developing countries are at risk from the direct and indirect impacts and effects of climate change that are classified the following manner (Wilbanks et al., 2007; Bartlett et al., 2009): i. Changes in means (temperature, precipitation, sea level rise); ii. Changes in extremes (Extreme rainfall/Tropical cyclones, drought, heat- or cold-waves); iii. Changes in exposure (population movements and biological changes. Where it is important for policy makers, researchers, decision-makers and urban citizens to produce and deploy new and cleaner technologies and take actions and measures that involve some level of citizen participation; the instruments of policy mandates to active behavioural change should be adopted (Dietz and Stern, 2008; Shwom et al., 2010). From this perspective, an adequate urban climate governance involves the formulation of adaptation strategies and policy measures that require major societal, economic, and lifestyle changes for the participatory support of achieving sustainable development, especially in cities. The key to achieving this goal is to understand the opinions and perceptions of urban people on climate change.

Different research studies have analysed perceptions of climate change over the last few decades in the world using surveys. According to Capstick et al. (2015), studies on public perceptions of climate change can be divided into four types: 1. Studies to understand the nature of public awareness of climate change, which

* Corresponding author. School of Administration, Universidad del Rosario, Bogotá, Colombia.
E-mail addresses: cipmusa@yahoo.com (C.I. Pardo Martínez), william.alfonso@urosario.edu.co (W.H. Alfonso Piña), sfletscher@ocyt.org.co (S.F. Moreno).

https://doi.org/10.1016/j.jclepro.2017.12.246
0959-6526/© 2018 Elsevier Ltd. All rights reserved.

were mainly conducted in developed countries, e.g., Kempton (2015), analysed knowledge of global climate in the US from 1989 to 1992 and suggested a widespread lack of knowledge and that better communication could improve the public's awareness on this topic; Reynolds et al. (2010) compared two surveys on climate change in the US (1992 and 2009), identifying that the last survey had a higher awareness and knowledge of some climate change causes. 2. Research on public perception trends at the macro-level has been conducted to determine public perceptions in a variety of fields, such as awareness and understanding, existence of phenomena, causes and effects, e.g., Brechin (2010) studied the relationship between climate change and the public from different surveys in the US, identifying that the individuals and social groups that understand climate change will remain generally the same; Poortinga et al. (2013) evaluated the perception of the existence of climate change taking into account British public attitudes on climate change and energy security and offered a comparison between Britain and Japan on the awareness of climate change before and after the Fukushima accident, respectively. This study concluded that climate change is occurring and it is necessary to take adequate measures, especially in regards to energy security; Yeager et al. (2011) assessed public attitudes related to causes and effects of climate change, finding that climate change is one of the world's most serious problems due to impacts related to poverty, hunger lack of drinking water, and the economy. 3. Studies that determine the reasons behind changing public perceptions, mainly by the occurrence of significant events (e.g., Leiserowitz et al., 2013 determined that “climategate” had an important effect on the public beliefs in climate change and trust in scientists), meteorological data (e.g., Deryugina (2013) analysed how local temperature fluctuations influence what individuals believe about these effects, finding that longer-run fluctuations are significant predictors of attitudes), and socioeconomic variables (e.g., Shum (2012) studied the effects of economic growth rates on people's attitudes regarding the mitigation of Greenhouse Gas (GHG) Emissions in the European Union, determining that the economy has a significant effect on people's perceptions towards the mitigation of GHG emissions). 4. Research about the temporal component of public perceptions to determine culturally specific notions of climate change using qualitative methods, e.g., Lavrillier (2013) investigated how climate change is perceived, and how it causes economic, social and ritual changes, finding changes for adaptation to climate change. However, the majority of these studies of perception have been generated in developed countries and with low vulnerability to climate change, where it is important to increase analysis of public perceptions from urban approaches, especially in cities that begin to undergo the effects and consequences of climate change to determine and assume new strategies and challenges that implies this phenomenon.

In the context of Latin-America, diverse studies on public perceptions of climate change have been developed, especially with regard to perceptions in indigenous and local communities, where the results indicate that main perceptions on climate change are related to climatic variability, increasing temperature, changes in rainfall and cultural habits, scarcity of water resources, and health problems (Forero et al., 2014) demonstrating that studies on climate change perceptions are limited within the Latin American context.

Studies on climate change in cities have analysed mainly the following issues: i. Climate change and urbanization where Karaca et al. (1995) studied the consequences of urbanization and climates of two largest cities in Turkey and Gill et al. (2007) analysed the relationship between green infrastructure and climate change. Both concluded a direct relationship between these two issues. ii. Differences of climate change in urban and rural areas where Zelenáková et al. (2015) determined that temperature in urban areas, which are higher than in rural areas and Oleson (2012) found that urban and rural areas react differently to climate change. These studies suggested the importance to formulate adequate instruments to analysis climate change according to area or sample. iii. Changes in climate extremes in urban areas where Mishra et al. (2015) and Donat et al. (2013) suggested increases in heat waves and hot nights across the urban areas, which could generate health problems and higher heating and cooling demands, among other. iv. Planning and adaptation to climate change where Gustafsson et al. (2015), Wamsler et al. (2013) and IPCC (2007) determining that in the urban planning practices must include measures that lead all type of risk factors taking into account environmental, socio-cultural, economic and political aspects in systematized and systematically form. These studies demonstrate the importance of climate change in urban areas and how opinions and ideas of population are important to determine adequate measures according to effects and impacts on changes in weather and environment of cities.

With this background, the goal of this research was to gather and analyse the perceptions of the urban population of Bogotá regarding climate change. The specific objectives of the study were to conduct an in-depth survey on climate change in Bogotá using statistical techniques that allow to infer reliable results for whole population of the city determining the positions and beliefs, information habits, institutionalism and governance, and empowerment of science and technology related to climate change, as a contribution to understand perceptions on this issue in a city with higher vulnerability, which generate inputs to develop adequate instruments to prevent and mitigate climate change in the urban context.

In the context of Latin America, and cities in particular, studies on the opinions of climate change are limited, and the aim of this research is to analysis the knowledge and attitudes of urban population as an input to develop adequate programs to prevent, mitigate and adapt to this phenomenon.

The paper contains five sections. The first section is the introduction. The second section explain Bogotá as case study. Third section describes the methods used in this study for an urban survey on climate change opinions. The four section presents the main results and discussion of the survey in the urban context of Bogotá. The last section presents a set of conclusions.

2. Bogotá as case study

Bogotá is selected in this study because it is a city that is particularly vulnerable to climate change, given that its population has been established in areas that are prone to flooding and in unstable lands of the high sierras, their residents depends on the mountains and grasslands neighbouring the urban area for water supply, and in the few last years this city has suffered extreme weather events by La Niña and El Niño phenomena, the first causes a significant intensification in water flowing through the mountains, exceeding the capacity of these degraded landscapes to filter and absorb it, whereas the second show an important decrease of water supply and high vulnerability to forest fires and droughts (UNDP, 2010; Andrade, 2014), which impact human health, hence, it is critical to protect this city against climate impacts.

Moreover, Bogotá generates 0.36% of global CO_2 emissions; where it is important to decrease GHG emissions to maintain or increase air quality, reduce effects of climate change on health, water, energy and food availability and vulnerability to strength and maintain quality of life. Moreover, to promote programs related to energy efficiency in the industrial sector (Pardo Martínez, 2014).

With respect to projections of temperature and emissions, for the next years, it is expected to increase the monthly average temperature, which can produce a decline of 70.5% forests and 54.6% moorlands (Paramo) at the whole area. With respect to rainfall, in the East and some areas of Chingaza moorland, it is expected a decrease on rainfall (10–20%) causing serious repercussions in the water supply in aqueducts and reservoirs. In contrast, in the South (Sumapaz) it is expected an intensification of precipitation (20–30%) for the period 2041–2070 causing frequent and intense flooding a landslide in the city (Carbonn, 2010).

Moreover, in the last years, Bogotá as the main city of Colombia have experienced different climate-related disasters, including floods, droughts, storms and extreme temperatures. These events have led to human casualties and destroyed homes, livelihoods, and infrastructure; the total losses from natural disasters account for 1.1% of the national gross domestic product (GDP) in this country (DNP and IDB, 2014), demonstrating the importance of understanding the perceptions, awareness, attitudes and knowledge of the urban population regarding climate change.

3. Methods

The method for this research was chosen to facilitate the presentation of data and information with the goal of understanding and analysing the main opinions, attitudes, public ideas and knowledge on climate change and its process in the daily life in Bogotá city. The research method included various elements, such as sample selection, data collection, evaluation of the validity and reliability of the data, and data review and evaluation.

The study's research format was inductive, meaning that the data gathered and the analysis allowed for the development of different findings that enrich the available literature on public perception of climate change in urban context with higher vulnerability.

For this study, a survey was conducted with urban population, where a descriptive quota sample of the Bogotá's population aged 18 years and older was interviewed face-to-face in their own homes by Colombian Observatory of Science and Technology (OCyT) and Specialized Systems of Information (SEI) between 1 April and 15 May 2016. Interviews were conducted in different zones of Bogotá as capital city of Colombia that has the largest population and economy in terms of Gross Domestic Product (DANE, 2015) and typical city of developing country with high vulnerability to climate change.

Zones of Bogotá were designated randomly from a stratified sample based on the criteria of strata and age, where sampling was random and stratified. Stratified sampling allowed for a representative sample of different categories of vulnerability, and the technique used for the sample design was principal component analysis (PCA), which was used to categorize the zones in Bogotá; zones in the city were assigned using the technique of optimal X allocation taking into account weather characteristics, and the same number of households was assigned to each zone of city.

Bogotá consists of a population of 7.87 million with 2.55 million households, where it calculated a sample size of 448 following Masud et al. (2015, 2017). 480 households were contacted with the response rate 93.3% where 32 questionnaires were rejected generating 448 effective surveys. This sample size is adequate taking into account Leedy and Ormrod (2010) that consider that for a population size of above 5000 a sample size of 400 is statistically robust and reliable. Pilot test was conducted on 15 households to determine response time, the precision and understanding of the questions with the aim to assurance that the instrument was relevant and appropriate for the study.

To guarantee the representative of sample in the selection in the city was drawn with a probability proportional to population size (PPS) with a design πpt where the inclusion probability is proportional to absolute value. In this study, it is used Horviz-Thompson estimator that to estimate the total of the observed variable y in the sample according to Gutierrez (2011) (see equation (1)).

$$\widehat{t}_{y,\pi} = \sum_{S} \frac{y_i}{\pi_i} = \sum_{S} d_i y_i \tag{1}$$

Where π_i it is the probability of inclusion k-th element, which it is given by inclusion probabilities of four sampling stages proposes in this study.

From this estimator for a total, it is necessary the estimation of proportions to obtain the averages and percentages according to Särndal et al. (1992) (see equation (2)).

$$\widehat{R} = \frac{\widehat{\widehat{t}}_{y,\pi}}{\widehat{\widehat{t}}_{z,\pi}} \tag{2}$$

To establish expansion factors was used PPS sampling without replacement (see equation (3)) and a simple random sampling without replacement (see equation (4)).

$$\pi_k = \frac{n x_k}{t_x} \tag{3}$$

$x_k$is the criteria in absolute value for zone of city k.

$$\pi = \frac{n}{N} \tag{4}$$

n and N vary depending sampling stage that in this study are four (I: Zone selected, II: Socio economic strata selected, III: Blocks of city selected, IV: Households by block selected). Inclusion probabilities per stage are formulated following the methodology developed by Särndal et al. (1992). Expansion factors for every sampling stage are the inverse of each inclusion probabilities and the final factor of every unit is the multiplication of the inverse of probabilities of all stages (see equation (5)).

$$EXF_{Basic} = EXF_I \cdot EXF_{II} \cdot EXF_{III} \cdot EXF_{IV} \tag{5}$$

To generate adjusted expansion factor by non-response, this is calculated for selection stages of blocks and households according to equation (6).

$$F_{Adjusted} = \frac{n + n_{ad} - n_{fu}}{n + n_{ad} - n_{fu} - n_r} \tag{6}$$

where n = expected amount of sample; n_{ad} = additional amount of elements or observed units that appear default in framework; n_{fu} = amount of elements or units outside the universe; n_r = amount of rejections or non-response or absentees.

With these factors (blocks and households), these are multiplied by basic factor to generate expansion factor adjusted by hedging (see equation (7)).

$$EXF_{END} = EXF_I \cdot EXF_{II} \cdot \left(EXF_{III} \cdot EXF_{adjusted\ block}\right) \cdot \left(EXF_{IV} \cdot EXF_{adjusted\ household}\right) \tag{7}$$

Estimation of variance is according to Horvitz-Thomson (see equation (8)) taking into account that π_k is the inclusion probability of municipality within stratum h, with $\widehat{t}_{yk}$ total estimated of variable y for municipality k, and $\widehat{t}_{yh}$ total estimated of variable y for stratum h.

$$\widehat{V}\left(\widehat{t}_y\right) \cong \sum_{h=1}^{5} \frac{1}{n_h(n_h-1)} \sum_i \left(\frac{n_h \widehat{t}_{yk}}{\pi_k} - \widehat{t}_{yh}\right)^2 \tag{8}$$

In this study, it is necessary to calculate percentages or ratios; the estimations of variance for ratios follow the lineal approach of ratio through Taylor series that according to Särndal et al. (1992) it is expressed with equation (9).

$$\widehat{U}_k = \left(y_k - \widehat{R}\, z_k\right) \frac{1}{\widehat{\widehat{t}}_z} \tag{9}$$

Equation (9) and replaced variable y for total estimation; lineal approach is equation (10) based on Särndal et al. (1992). Taking into account that $\widehat{t}_{yk}$ is in function of variable $\widehat{u}_k$.

$$\widehat{U}\left(\widehat{R}\right) \cong \sum_{h=1}^{5} \frac{1}{n_h(n_h-1)} \sum_i \left(\frac{n_h \widehat{t}_{yk}}{\pi_k} - \widehat{t}_{uh}\right)^2 \tag{10}$$

Moreover, for auxiliary variables (x) or administrative registers are used calibration estimators to guarantee the balance for population characteristics that are of interest for study. This method calculates weights w_k close to the inverse of inclusion probability of k-th element d_k, the estimations must fulfil the restriction of equation (11) according to Gutierrez (2011).

$$\sum_{k \epsilon S} w_k X_k = t_x \tag{11}$$

The development of expansion calibrated factors used calibration technique from Calibrate 1 procedure to generate calibrated weights to estimate and evaluate the estimation quality of the study achieving high reliability and standard error and margin error less than 10%.

3.1. Survey design

Personal interviews were conducted by fully trained and supervised market and opinion research interviewers and took (on average) 30 min to complete. Interviewers introduced themselves as being from Colombian Observatory of Science and Technology (OCyT), an independent research organization carrying out a survey on behalf of IDEAM and PNUD regarding the perceptions of climate change in Colombia. All surveys were anonymous. No incentives were offered for participation. In total, the survey was composed of 25 questions and five sections about socio-demographic features and climate change.

The survey questionnaire was designed taking into account the requirements of the Antigua Manual regarding perception surveys from five dimensions with respective sub-dimensions (see Table 1 and RICYT, 2015). The survey questionnaire was designed following different perception studies such as the survey of environment and climate change in Costa Rica (PNUD, 2014), climate change perception in Bangladesh (The Asia Foundation, 2012), and research of perception studies around the world (Capstick et al., 2015).

4. Results and discussion

This section shows the main results of the urban survey on climate change in Bogotá that was calculated with statistical techniques of high reliability. This study indicates different approaches on public perceptions of climate change taking into account the socio-demographic characteristics of population. In general, population of Bogotá if it considers that climate change is happening and it is perceived through changes in temperature and rainfall, it is caused by human activities and in this city the actions in relation to climate change are limited.

4.1. Socio-demographics characteristics

An urban representative quota sample of 246 people aged 18 years and older was interviewed face-to-face in their own homes and represents 2557100 of citizens of Bogotá. Women 61.64% and men 38.36% answered the survey. The majority of respondents (59.24%) had primary and secondary education.

4.2. Positions and beliefs regarding climate change

These questions are focused to analyse beliefs and knowledge regarding climate change for urban population. In general, these illustrations answer cultural and social paradigms around climate, its variations and risks. These questions allow the most important images and their dynamics according to the respondents to be acknowledged.

The main results on the positions and beliefs of climate change in Bogotá are the following: All respondents consider that climate change is real. Urban respondents consider that over last five years, the annual average temperature is warmer (52.05%) and very variable (32.03%) and the amount of the rain has decreased (33.72%) or been variable (33.63%) especially in the ranges from 16 to 24 years old and from 55 to 64 years old and the majority of respondents that consider that annual average temperature and the amount of the rain have been variable in the last years, which concurs with weather conditions of Bogotá with cold temperature in the morning and the late afternoon and rain may be present at any time of the year in this period.

The main cause of climate change is human activity (see Fig. 1) for majority of respondents, which corresponds with relationship with generation of greenhouse gas emissions by transportation or industrial activity that characterize the cities as Bogotá.

Respondents relate to climate change with the following words: temperature, climate change, hydrological change, droughts, and rainfall, among others. Fig. 2 describes hierarchical connections for words related to climate change (from a sequence by repetition frequency) that it generates among words and concepts with the increased number of responses by survey respondents and how these words and concepts are related (e.g., global warming is one of the words the most often mentioned and is interconnected with temperature and pollution, and pollution are related to change and then with droughts and this with forest fire).

The availability of food, health, infrastructure and quality of soil (erosion) are the main factors that are threatened by climate change in Bogotá, whereas household and availability of water are less threatened by climate change according to the urban respondents' answers of Bogotá (see Fig. 3). According to World Bank (2010a) climate change generates severe threats to urban infrastructure, quality of life (health, food availability, etc.) and whole urban systems due to strange climate events and trends, which concurs with results of survey applied in Bogotá and study of main diseases generated in the city related to effects of climate change

Table 1
Survey dimensions of the national survey of climate change in Colombia.

Dimension	Sub-dimension	Number of questions	Sample Questions
Socio-demographics characteristics	Age, gender, ethnic group, occupation, education level	4	
Positions and beliefs regarding climate change	Concepts of climate change, causes and consequences of climate change, climate variability and vulnerability to climate change	12	From year 2011 to today, the annual average temperature in this municipality has been: … From year 2011 to today, the amount of rain (rainfall) in this municipality: …. What words or phrases do you think about when we talk about climate change? Do you consider that climate change can threaten the following aspects in your municipality/city? When do you consider that the consequences of climate change will occur?
Information habits	Information, sources and level of information of climate change	3	How informed are you about climate change? Through what media platform do you mainly obtain information on climate change? Can you name a program/newspaper/magazines/web page that you consult/seek to inquire information on climate change?
Institutionalism and governance	Climate change policies, institutions that work by climate change, promote actions on climate change	3	In the last year until yesterday, have you participated in the following forums for public participation for issues related to climate change? Of the following entities, which take action to combat climate change in your municipality or city?
Empowerment of science and technology related to climate change	Education and practices (mitigation and adaptation) on climate change	4	In what ways have you modified your behaviour in response to climate change? What actions/practices have you applied to contribute to the reduction of the associated effects of climate change? Which of the following actions have you performed in addressing the consequences of climate change?

such as respiratory diseases (Pardo Martinez and Alfonso, 2014).

The urban respondents of Bogotá indicated that the main causes of climate change (see Fig. 4) are deforestation (31.91%), inadequate solid waste management (26.59%) and air pollution generated by industries (21.18%) especially in the ranges from 25 to 44 years old indicating that causes of climate change are related to contamination in urban areas. These results concur to data of IDEAM that demonstrated a gradual decline of Colombian natural forest from an area of 56.4% in 1990 to 51.7% in 2014 and Pardo Martinez and Alfonso (2016) in the context of energy efficiency in manufacturing industries of Bogotá.

The survey also suggested that 54.34% of respondents consider that the consequences of climate change have occurred for more than 10 years, whereas 45.66% consider that the consequences of climate change have occurred for more than 30 years. These results indicate that urban population has the opinion that climate change is a phenomenon that it is perceived as some has been happening in the last decades and not only as a stand-alone issue.

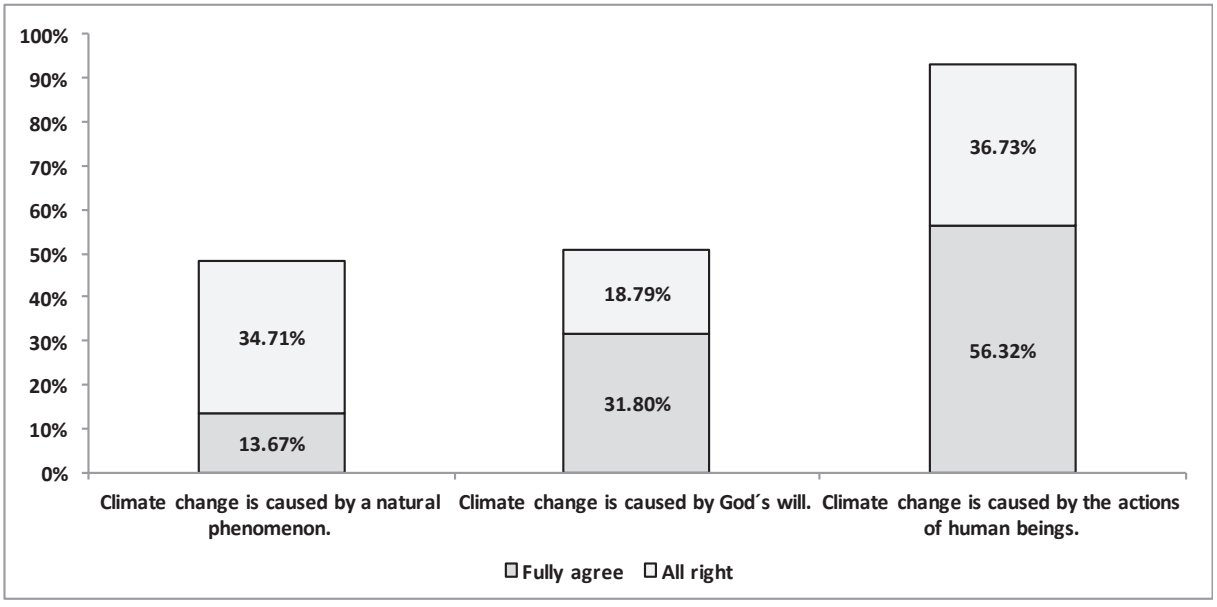

Fig. 1. Causes of climate change according to Bogotá's citizens.

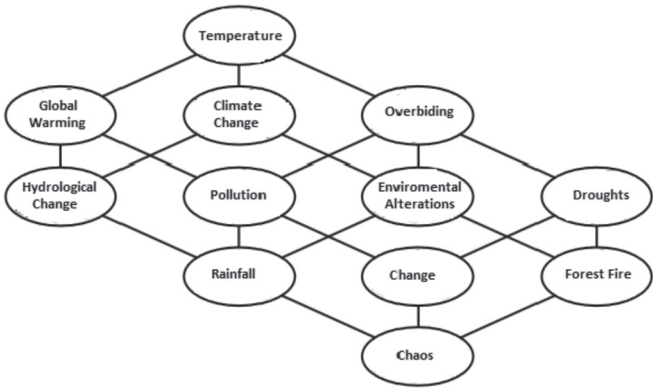

Fig. 2. Words related to climate change in Bogotá.

41.29% of the Bogotá's respondents understand about greenhouse gas emissions and considers that following activities generate Greenhouse Gas (GHG) Emissions: industrial activities, fires and motor vehicles, waste management, and burns, whereas agricultural and livestock activities are identified as little generators of GHG emissions. These results demonstrate that urban population associate urban activities with generation of GHG due to higher relationship with daily activities in the city.

In terms of how the urban population is affected by climate change, the results indicate that 88.16% of respondents consider that the world population will be affected without distinction, and all respondents consider that the Colombian population, population that live in the sea shore and the side of the river will be greatly affected.

Within a Bogotá city, unexpected changes in temperature, droughts, increasing food prices, forest fires, and extreme hot or cold conditions are situations that have been associated with climate change in the last years indicating that perception is close related to environment and ecosystems predominant in the urban area. Moreover, when the survey was applied, Bogotá has experienced an intensive period of forest fires, which could have generated a higher concentration of answer related to this situation and direct relationship with climate change.

These results indicate that the Bogotá's population considers that climate change is occurring and has affected their life, which is consistent with other studies in developed and developing countries where climate change has become a priority (Corner et al.,

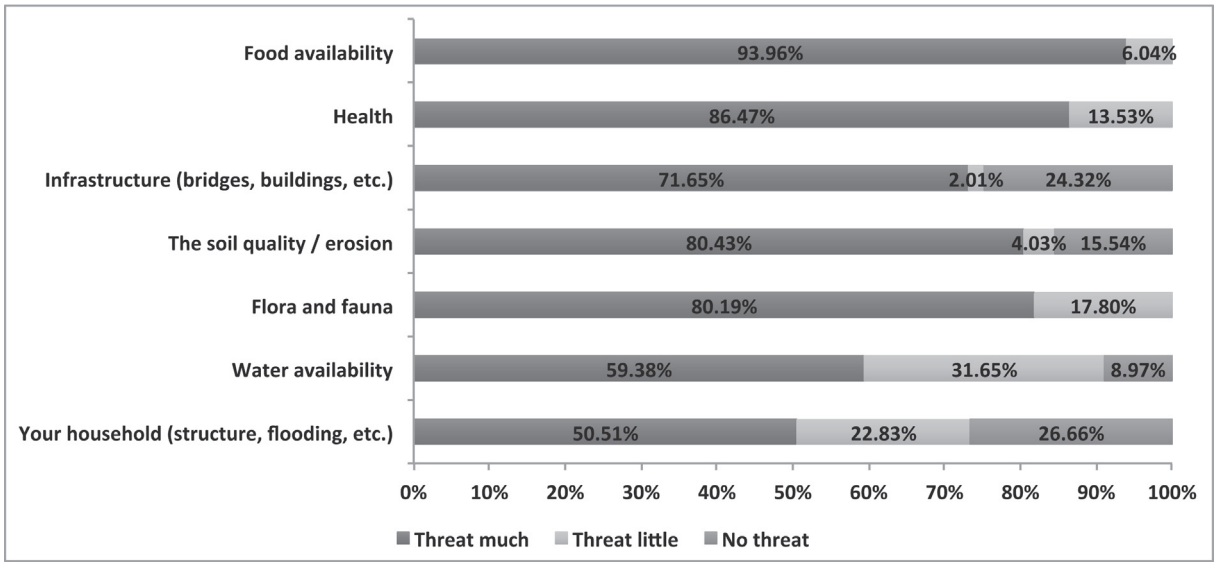

Fig. 3. Main factors that are threatened by climate change in Bogotá.

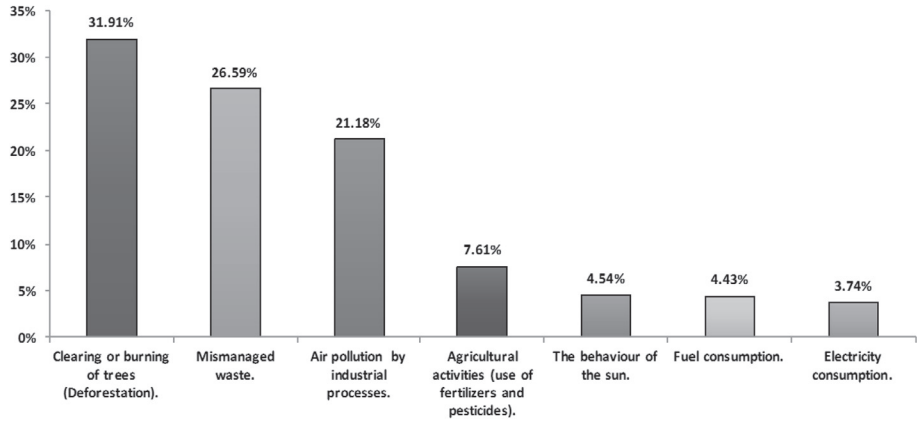

Fig. 4. Main causes of climate change according to Bogotá's citizens.

2011; The Asia Foundation, 2012; Leiserowitz et al., 2013; Nisbet and Myers, 2007) and that have enacted a number of policies and initiatives that allow for the adaptation and mitigation of climate change; this is especially important in urban cities that have a high vulnerability to climate change especially in developing countries.

Studies of The Ministry of Environment (2016) have established that main impacts of climate change in Colombia will be given in coastal zones by the threat of flooding affecting 2% of population and 2.2% of gross domestic product, 50% of population will be affected by modifications in the variation in hydraulic regime, agricultural sector and soil with high potential of desertification in several regions of country and an increase of tropical diseases. These impacts concur to results of urban survey on climate change in Bogotá.

4.3. Information habits

This dimension seeks to recognise the representation of climate change in the media to determine whether the media effectively informs the urban population about climate change. This information is key to determining appropriate and relevant communication strategies for climate change in urban areas to develop adequate instruments for prevention, mitigation and adaptation.

88.82% of urban respondents consider that they are not sufficiently well informed on climate change whereas 6.91% of respondents consider that they are very well informed especially in respondents in the ranges from 16 to 24 years old. These results indicate the importance to promote and strength communication strategy with the aim to avoid false or erroneous information on climate change and generate information based on evidence from reliable research to empower population on preventive, mitigation and adaptation measures especially in urban context. Moreover, young people has been greater interest in climate change and environmental problems where they have a important role in combating climate change (Pandve et al., 2009).

The main media platform to inform them of climate change is television, followed by the Internet. The programs that are recognized to provide information about climate are mainly the *Discovery Channel*, *Week radio_No Numeral*, *RCN newscast*, etc. and web pages of public offices as IDEAM and the Ministry of Environment. Fig. 5 shows hierarchical connections for media platform (e.g., IDEAM is one of the words the most often mentioned and is interconnected with Weekradio and the Ministry of Environment the both words are interconnected with Corpoamazonia and this last word is related to Geoplanet).

These results demonstrated that the Bogotá's population has an interest in climate change, which is consistent with the findings of the III and IV national surveys on public perceptions of science and technology applied in Colombia in the years 2011 and 2015 (Colombian Observatory of Science and Technology, 2014, 2015) in which the majority of the population use television and the Internet for information regarding science and technology and over 50% of the population has interest in environmental topics and affirm that they are informed or not sufficiently well informed.

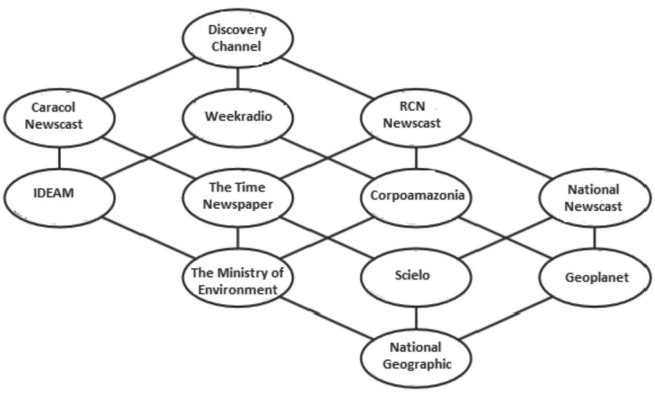

Fig. 5. Programs recognized to inform the public about climate change.

An adequate communication strategy to increase awareness on climate change must include the following elements: i. Training and raise awareness concerning the climate change adaptation among all stakeholders; ii. Promotion of public participation instruments and facilitate use and application for all population; iii. To provide adequate communication tools for all segments of population; iv. Generation constantly of appropriate communication strategy on climate change from different approaches (prevention, adaptation and mitigation); v. To foster urban population understanding of the topics of climate change for communicated decision-making and implementation of corrective procedures and good practices to prevent environmental problems (UNDP, 2012; Space, 2009).

4.4. Institutionalism and governance

This section of survey seeks to analysis the knowledge of urban respondents related to institutions or entities that promote climate change in the city. Moreover, it establishes the level of involvement or relevance of respondents to contribute in decisions or actions regarding climate change through different mechanisms than those offer by the Colombian and Bogotá's government.

To determine the government activities or programs regarding climate and environmental problems, the survey included some questions in which education campaigns and programs or projects are the actions executed by the Bogotá's government (see Fig. 6). However, none of respondents consider that investments of financial resources for climate change are adequate indicating that Bogotá's citizens feel that definitive the budget to mitigate, prevent and control climate change lack the specific actions. Likewise, it considers that research in this topic is limited. These results demonstrate the importance for Bogotá's citizens of the need for the government to evolve effective governance and policies related to climate change with local, regional and urban effects and impacts.

Less than 10% of respondents have used forums for public participation on climate change, where highlights: environmental municipal councils, committees of citizen participation and community action councils. These results demonstrate the lack of interest in the climate change in urban contexts.

The government offices most recognized to conduct actions in response to climate change are the Ministry of the Environment, Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) and Corpoica. However, 32.73% of respondents considered that no entity promotes action to prevent, combat and control climate change in urban areas and that city is not ready to face climate change and its consequences over the next five years.

These results indicate that the Bogotá's population considers that the role of government and different institutions are still marginal, suggesting that it is important to make increased efforts in activities on awareness and institutional reinforcement in relation to climate change that should be integrated in all areas of public policy, particularly economic and social policies and regions that have important roles in climate policies (OECD, 2007; Galarraga et al., 2009).

In the formulation and design of climate change governance, it is important taking account the following: i. Improved integrate sectorial policies horizontally (cross-sectorial) for impacts and adaptation efforts cut across policy sectors; ii. Better incorporation

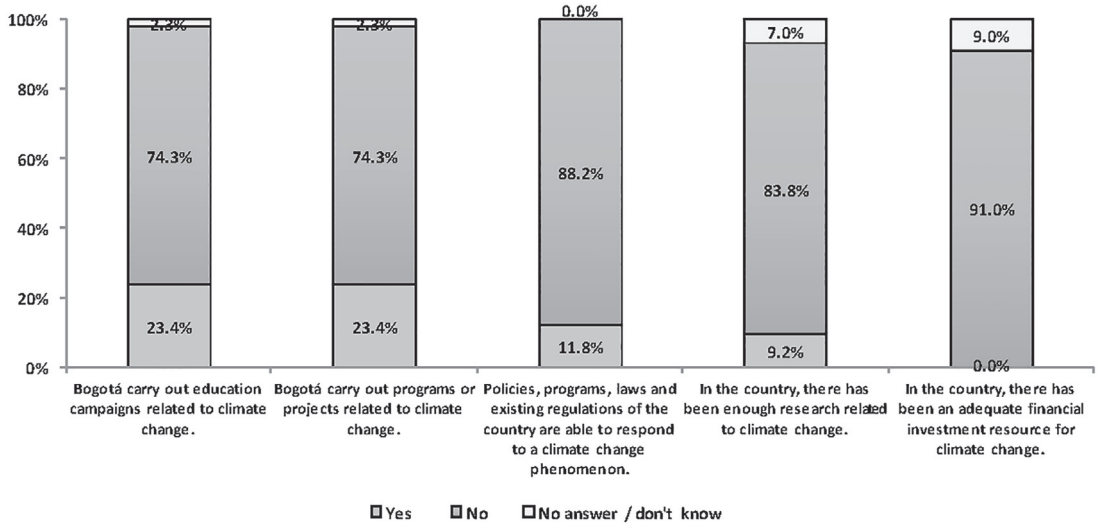

Fig. 6. Perceptions related to institutional activities on climate change in urban areas and country.

of policies vertically (across levels of government) for impacts and adaptation efforts cut across levels of government; iii. Increase the knowledge - base of policies and facilitate participation taking into account the uncertainty of climate scenarios, impacts and vulnerabilities and the effectiveness of measures; iv. Simplify 'procedural justice' by involving those in policymaking who are affected most by climate change (Steurer et al., 2010; Bauer et al., 2011).

Other important point is that urban areas are complex systems where service delivery mixes with robust infrastructure and social and political aspects that define much of the success or failure of social and economic policies, where for climate change it must improve the city's resilience that implies mainly: robust decision making, social inclusion, urban risk assessments, emergency preparedness, greater adaptive capacity, protection and integration of key ecosystem services, among other (World Bank, 2010b; Staden, 2014).

Colombia has developed a Strategy of Low Carbon Development that included the following issues: i. An analytical phase to identify and formulate mitigation measured for productive sectors; ii. the development of action plans for mitigation and studies of the co-benefits of mitigation measures; iii. the implementation of a measuring system of mitigation actions; iv. capacity-building; and v. communication strategies. This strategy has allowed for the development of eight plans of action for the main productive sectors to improve sustainable development and decrease GHG emissions. According to this strategy, Bogotá developed a Plan of Adaptation and Mitigation to Climate Change with five objectives through District Secretary of Environment (see Table 2) that taking into account the results of survey require more divulgation and diffusion in the Bogotá's population with the aim to achieve the reduction of climate change effects and higher adaptation a new conditions of environment.

4.5. Empowerment of science and technology related to climate change

This dimension includes questions to determine the actions and process that respondents make every day related to climate change. Moreover, these questions allow for an understanding of how people use the scientific knowledge on climate change in their experiences to generate involvement and participation.

In regards to actions and practices for adaptation to climate change, 89.02% of respondents have not applied any practice or action and the main modifications of behaviour in response to climate change by the respondents are the following: reducing water consumption (75.21%), changing of the manner of dress (59.62%), changing of diet plan (23.16%) and changes in infrastructure (22.88%) indicating that climate change generates in the population modifications in everyday habits due to variations of temperature and precipitations. In case of reducing water consumption, the results concur with different campaigns from local government in the last decades, application of new tariff system and better public awareness of the consequence of the rational use of water (Alfonso and Pardo Martínez, 2014).

The main activities identified by the respondents to contribute to the reduction of the associated effects of climate change are the following (see Fig. 7): reduce energy and water consumption, use alternative energy systems and recycle materials, whereas to avoid localization in risk areas by landslide and/or flooding and plant trees were not considered (0% of answer). These results demonstrate that citizens of this city gradually become aware of the importance to protect the environment and prevent climate change from daily activities, which generate cultural changes and higher empowerment of society around urban problems related to ecosystem and nature. However, these results could be associated with high costs in public services, especially electricity and potable water. Reference is also made to the recycling of materials, the use of renewable energy as solar energy and the use of alternative modes of mobility, such as cycling. In general, there is a trend towards the use of green products in domestic consumption, associated more with the marketing of sustainable products, which are not yet rooted in consumption, nor has its effect on the environment been verified which concurs with Yu et al. (2017) in the context of Taiwanese undergraduate students.

The findings of this study indicate that the urban citizens of Bogotá have generated different perceptions and understanding on climate change, for which it is important to design and apply new strategies to empower the urban population on the importance and actions for adaptation or mitigation of climate change. Additionally, the government should strengthen climate change governance, especially in the urban regions that are most affected by this situation taking into account that today and the future cities agglomerate the majority of population.

Table 2
Bogotá's plan of adaptation and mitigation to climate change.

Goals	Programs
Goal 1: To cut Bogotá's carbon dioxide (CO_2) emissions	- Sustainable mobility - Zero waste - Eco-efficiency in responsible consumption and production systems - Sustainable building
Goal 2: Increase the adaptive capacity of the city to climate change	- Eco-urbanism and territorial planning for adaptation - Recovery the Ecological main structure of Bogotá and the region - Scaling of green space coverage - Research on health Impacts of Climate Change
Goal 3: Save and manage integrally the water	- Sustainable drain system - Reduce water losses - Increase rainwater uses - Aquifer protection - Bogotá river basin recovery
Goal 4: Consolidate a system of environmental governance to tackle climate change collectively	- The construction of the public participation through formal and informal mechanism in the decision-making processes that impact the city. - To strength capital social (the capacity of organization, appropriation of knowledge, understanding of the environment and conflict resolution competence.
Goal 5: Promote a transformative cultural change, according to new climate challenges that are imposed	- To organize and achieve synergies that increase social and cultural appropriation for adaptation to climate change. - Formulation of communication and education strategies.

Source: District Secretary of Environment (2015.

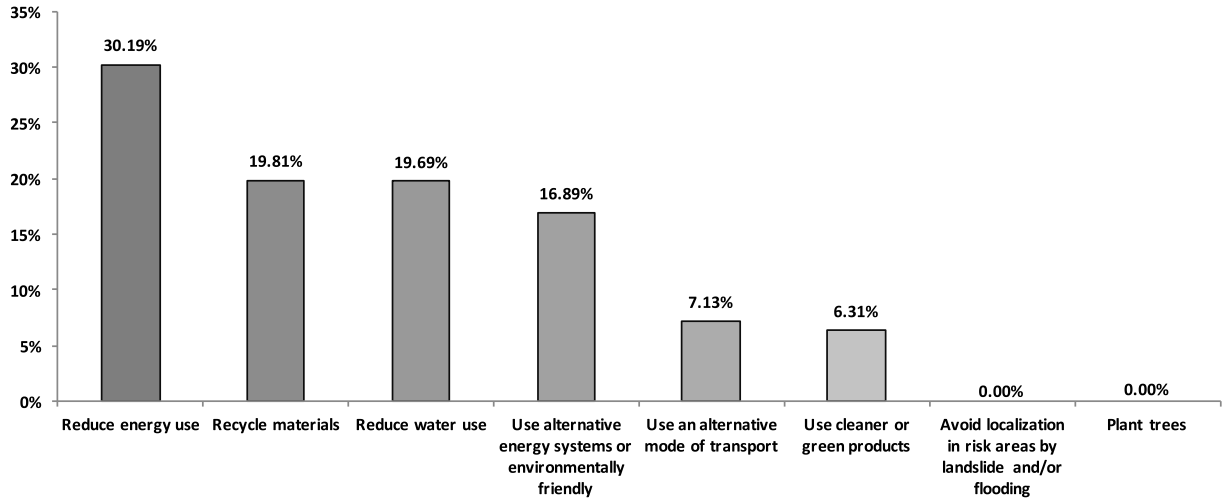

Fig. 7. The main practices identified by the respondents to contribute to the reduction of the associated effects of climate change in Bogotá.

5. Conclusions

Climate change is disturbing urban areas and their citizens, especially the poor, and more severe effects are estimated as climate extremes and variability increase, as it is the case of Bogotá. Hence, the results of this study have demonstrated that the 100% of the Bogotá's interviewed believe climate change to be an important issue. They note that it is real and that human activity is a principal contributing factor (56.32%). The study identified that the Bogotá's citizens has perceived changes in temperature and rainfall over the last five years, and these changes have generated threats to their habitat in the form of droughts, rising food prices, forest fires, among others. The main media platforms to inform the public on climate change are television and the Internet.

On the whole, this research reveals that climate change governance has gaps because majority of respondents consider that the city does not execute or apply actions to combat climate change, and less than 10% have used forums for public participation on climate change. Moreover, the majority of Bogotá's citizens have not applied any practice or action to adapt to climate change.

These results show the importance to climate change for the urban population of Bogotá. It is important to design strategies and programs in which citizens can become more involved in actions to prevent, mitigate and adapt to climate change and in which government and the media also play significance roles. Identifying current perceptions is not sufficient; it is also necessary to identify and analyse climate change from an integral perspective that guarantees effective migration strategies, such as the development of a low carbon economy.

Acknowledgments

Research for this study was funded by the United Nations Development Programme – UNDP. We gratefully acknowledge research team that helped carry out this work as well as comments by anonymous reviewers to improve the manuscript.

References

Alfonso, W., Pardo Martínez, C.I., 2014. Urban material flow analysis: an approach for Bogotá, Colombia. Ecol. Indicat. 42, 32–42.

Andrade, A., 2014. Urban Jungle: How Vulnerable Is Bogotá to Climate Change Impacts? http://blog.conservation.org/2014/09/urban-jungle-how-vulnerable-is-bogota-to-climate-change-impacts/.
Bartlett, S., Dodman, D., Hardoy, J., Satterthwaite, D., Tacoli, C., 2009. Social Aspects of Climate Change in Urban Areas in Low- and Middle Income Nations. http://www.dbsa.org/Vulindlela/Presentations/Session1_Dodman_old.pdf, 2009.
Bauer, A., Feichteinger, J., Steurer, R., 2011. The Governance of Climate Change Adaptation in Ten OECD Countries: Challenges and Approaches. https://www.wiso.boku.ac.at/fileadmin/data/H03000/H73000/H73200/InFER_Discussion_Papers/InFER_DP_11_1__The_Gover nance_02.pdf.
Brechin, S.R., 2010. Chapter 10: public opinion: a cross-national view. In: Lever-Tracey, C. (Ed.), Routledge Handbook of Climate Change and Society. Routledge, London, pp. 179–209.
Capstick, S., Whitmarsh, L., Poortinga, W., Pidgeon, N., Upham, P., 2015. International trends in public perceptions of climate change over the past quarter century. WIREs Climate Change 6, 35–61.
Carbonn, 2010. Adaptation and Mitigation to Climate Change Plan for Bogotá (Bogotá Climate Action Plan). http://carbonn.org/uploads/tx_carbonndata/Brief%20[Ingles]%20-%20Plan%20Distrital%20de%20Adaptación%20y%20Mitigación%20al%20Cambio%20Climático%2019.10.pdf.
Colombian Observatory of Science and Technology, 2014. III National Survey of Public Perceptions of Science and Technology in Colombia. http://ocyt.org.co/es-es/Libros/ArtMID/543/ArticleID/237/Percepciones-de-las-ciencias-y-las-tecnolog237as-en-Colombia-Resultados-de-la-III-Encuesta-Nacional-de-Percepci243n-P250blica-de-la-Ciencia-y-la-Tecnolog237a.
Colombian Observatory of Science and Technology, 2015. Public Perceptions of Science, Technology and Innovation – ST&I, Chapter 8 in Colombian Science and Technology Indicators – 2015. http://ocyt.org.co/Portals/0/LibrosPDF/indicadores%202015_web.pdf.
Corner, A., Venables, D., Spence, A., Poortinga, W., Demski, C., Pidgeon, N., 2011. Nuclear power, climate change and energy security: exploring British public attitudes. Energy Pol. 39, 4823–4833.
DANE, 2015. National Statistics of Colombia (Population and Demography and National Accounts). http://www.dane.gov.co/index.php/estadisticas-por-tema.
Deryugina, T., 2013. How do people update? The effects of local weather fluctuations on beliefs about global warming. Climatic Change 118, 397–416.
Dietz, T., Stern, P.C., 2008. Public Participation in Environmental Assessment and Decision Making. National Academies Press, Washington, DC.
District Secretary of Environment, 2015. Bogotá's Plan of Adaptation and Mitigation to Climate Change. http://www.ambientebogota.gov.co/web/sda/577.
National Department Planning (DNP), Interamerican Development Bank (IDB), 2014. Economic Impacts of Climate Change in Colombia. https://colaboracion.dnp.gov.co/CDT/Ambiente/Impactos%20economicos%20Cambio%20climático.pdf.
Donat, G., Alexander, L., Yang, H., Durre, I., Vose, R., Dunn, R., Willett, K., Aguilar, E., Brunet, M., Caesar, J., 2013. Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: the HadEX2 dataset. J. Geophys. Res. Atmos. 118, 2098–2118.
Forero, E., Hernandez, Y., Zafra, C., 2014. Latin American perceptions of climate change: methodologies, tools and adaptation strategies in local communities. A review. Revista UDCA Actualidad y Divulgación Científica 17, 73–85.
Galarraga, I., González-Eguino, M., Markandya, A., 2009. The Role of Regions in Climate Change Policy. http://www.bc3research.org/lits_publications.html.
Gill, S.E., Handley, J.F., Ennos, A.R., Pauleit, S., 2007. Adapting cities for climate change: the role of the Green infrastructure. Built. Environ. 33, 115–133.
Gustafsson, S., Ivner, J., Palm, J., 2015. Management and stakeholder participation in local strategic energy planning e Examples from Sweden. J. Clean. Prod. 98, 205–215.
Gutierrez, A., 2011. Strategies of Sampling. Design of Surveys and Parameter Estimation, Universidad Santo Tomas, Bogotá.
Hunt, A., Watkiss, P., 2011. Climate change impacts and adaptation in cities: a review of the literature. Climatic Change 104, 13–49.
IDEAM, 2014. Sub-direction of Ecosystems and Environmental Information. Forest Group 2014. Project: Monitor System of Forest and Carbon. Bogotá, D. C., Colombia.
IPCC, 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA.
Karaca, M., Tayanç, M., Toros, H., 1995. Effects of urbanization on climate of Istanbul and Ankara. Atmos. Environ. 29, 3411–3421.
Kempton, W., 2015. How the public views climate change. Environment 39, 12–21, 1997.
Lavrillier, A., 2013. Climate change among nomadic and settled Tungus of Siberia: continuity and changes in economic and ritual relationships with the natural environment. Polar Rec. 49, 260–271.
Leedy, P.D., Ormrod, J.E., 2010. Practical Research: Planning and Design. Pearson, New Jersey, USA. ftp://doc.nit.ac.ir/cee/jazayeri/Research%20Method/Book/Practical%20 Research.pdf.
Leiserowitz, A., Maibach, E., Roser-Renouf, C., Feinberg, G., Howe, P., 2013. Climate Change in the American Mind: Americans' Global Warming Beliefs and Attitudes in April, 2013. Yale University and George Mason University. Yale Project on Climate Change Communication, New Haven, CT.
Masud, M.M., Al-Amin, Rulia A., Kari, F., Rafia, Afroz, Rahman, M.S., Rahman, M., 2015. Valuing climate protection by offsetting carbon emissions: rethinking environmental governance. J. Clean. Prod. 89, 41–49.
Masud, M.M., Azam, M., Mohiuddin, M., Banna, H., Akhtar, R., Alam, F., Begum, H., 2017. Adaptation barriers and strategies towards climate change: challenges in the agricultural sector. J. Clean. Prod. 156, 698–706.
Mishra, V., Ganguly, A., Nijssen, B., Lettenmaier, D., 2015. Changes in observed climate extremes in global urban areas. Environ. Res. Lett. 10, 024005.
Nisbet, M., Myers, T., 2007. The polls—trends twenty years of public opinion about global warming. Publ. Opin. Q. 71 (3), 444–470.
OECD, 2007. Climate Change Policies, Policy Brief. http://www.oecd.org/env/cc/39111309.pdf.
Oleson, K., 2012. Contrasts between urban and rural climate in CCSM4 CMIP5 climate change scenarios. J. Clim. 25, 1390–1412.
Pandve, H., Deshmukh, P., Pandve, R., Patil, N., 2009. Role of youth in combating climate change. Indian J. Occup. Environ. Med. 13, 5.
Pardo Martínez, C.I., 2014. The progress in sustainable energy in Colombia. In: Reiter, S. (Ed.), Book Energy Consumption. Impacts of Human Activity, Current and Future Challenges, Environmental and Socio Economic Effects. Nova Publishers, New York, pp. 153–166.
Pardo Martínez, C.I., Alfonso, W., 2014. Effects of urbanisation and suburbanisation on health in the Bogotá Region. In: Cotte, A., Pardo, C.I. (Eds.), Book Health, Violence, Environment and Human Development in Developing Countries. Nova Publishers, New York, pp. 147–164.
Pardo Martínez, C.I., Alfonso, W., 2016. Regional analysis across Colombian departments: a non-parametric study of energy use. J. Clean. Prod. 115, 130–138.
PNUD, 2014. Survey of Environment and Climate Change in Costa Rica. http://www.cr.undp.org/content/costarica/es/home/library/environment_energy/encuesta-de-ambiente-y-cambio-climatico-2014.html.
Poortinga, W., Aoyagi, M., Pidgeon, N.F., 2013. Public perceptions of climate change and energy futures before and after the Fukushima accident: a comparison between Britain and Japan. Energy Pol. 62, 1204–1211.
Revi, A., Satterthwaite, D.E., Aragón-Durand, F., Corfee-Morlot, J., Kiunsi, R.B.R., Pelling, M., Roberts, D.C., Solecki, W., 2014. Urban Areas. In: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part a: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 535–612.
Reynolds, T.W., Bostrom, A., Read, D., Morgan, M.G., 2010. Now what do people know about global climate change? Survey studies of educated laypeople. Risk Anal. 30, 1520–1538.
RICYT, 2015. Antigua Manual, Argentina. http://www.ricyt.org/files/MAntigua.pdf.
Särndal, C., Swensson, B., Wretman, J., 1992. Model Assisted Survey Sampling, Springer.
Shum, Y., 2012. Effects of economic recession and local weather on climate change attitudes. Clim. Pol. 12, 38–49.
Shwom, R., Bidwell, D., Dan, A., Dietz, T., 2010. Understanding US public support for domestic climate change policies. Global Environ. Change 20, 472–482.
Space, 2009. Climate Change Communication Strategy, a West Sussex Case Study. http://www.espace-project.org/part1/publications/reading/WSCCClimateCommunications%20Strategy.pdf.
Staden, R., 2014. Climate Change Implications for Cities. Key Findings from the Intergovernmental Panel on Climate Change Fifth Assessment Report. http://www.ipcc.ch/report/ar5/wg2/.
Steurer, R., Bauer, A., Feichteinger, J., 2010. The Governance of Adaptation to Climate Change: Taking Stock and Providing Guidance. https://www.wiso.boku.ac.at/fileadmin/data/H03000/H73000/H73200/Go-Adapt/Go-Adapt_Frame.pdf.
The Asia Foundation, 2012. Climate Change Perception Survey. www.asiafoundation.org.
The Ministry of Environment, 2016. Impacts of climate change in Colombia. www.minambiente.gov.co.
United Nations Development Programme (UNDP, 2010. Mainstreaming Climate Change in Colombia. Screening for Risks and Opportunity. http://www.undp.org/content/dam/aplaws/publication/en/publications/environment-energy/www-ee-library/climate-change/mainstreaming-climate-change-in-colombia/CC%20risk%20Mainstreaming%20Climate%20Change%20in%20Colombia-EN.pdf.
UNDP, 2012. An Integrated Communication and Advocacy Strategy for Enabling Pastoral Communities to Adapt to Climate Change and Restoring Rangeland Environments Programme.
United Nations, 2014. Department of Economic and Social Affairs, Population Division. World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352).
Wamsler, C., Brink, E., Rivera, C., 2013. Planning for climate change in urban areas: from theory to practice. J. Clean. Prod. 50, 68–81.
Weyrich, P., 2016. Barriers to Climate Change Adaptation in Urban Areas in Germany. Report Climate Service Center Germany, Hamburg. www.climate-service-center.de.
Wilbanks, T., Romero Lankao, P., Bao, M., Berkhout, F., Cairncross, S., Ceron, J.-P., Kapshe, M., Muir-Wood, R., Zapata-Marti, R., 2007. Industry, settlement and society. In: Parry, M., Canziani, O., Palutikof, J., van der linden, P., Hanson, C. (Eds.), Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.
World Bank, 2010a. Development and Climate Change: a Strategic Framework for

the World Bank Group, Interim Progress Report. The World Bank, Washington, DC.
World Bank, 2010b. Cities and Climate Change: an Urgent Agenda. Urban Development Series Knowledge Papers, vol. 10.
Yeager, D.S., Larson, S.B., Krosnick, J.A., Tompson, T., 2011. Measuring Americans' issue priorities a new version of the most important problem question reveals more concern about global warming and the environment. Publ. Opin. Q. 75, 125–138.
Yu, T.Y., Yu, T.K., Chao, C., 2017. Understanding Taiwanese undergraduate students' pro-environmental behavioral intention towards green products in the fight against climate change. J. Clean. Prod. 161, 390–402.
Zelenáková, M., Purcz, P., Hlavatá, H., Blištan, P., 2015. Climate change in urban versus rural areas. Procedia Eng. 119, 1171–1180.